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ABSTRACT

Through an examination of data on injuries to the lower extremities of varsity high school players, this study sought to ascertain 1) whether modified cleats brought about a reduction in the number and/or severity of such injuries; and 2) whether there existed an optimum combination of equipment for reduction in the number and/or severity of such injuries. After two years of gathering data and identifying other variables, it was determined that the lowest rate of serious knee injuries was incurred by youngsters outfitted with either low shoes, disc heels and ankle wraps or low shoes, shortie cleats and no ankle support. Data showed that those players with previous serious knee injuries were reinjured at a rate of 15 to 17 times greater than youngsters with no previous injury. Recommendations included: 1) all players be outfitted with low shoes and modified heels, discs, or shortened cleats; 2) consideration be given to modifying sole cleats; and 3) extensive efforts be undertaken to improve the physical conditioning of all football players. (KJ)

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William T. Callahan
Francis J. Crowley
J. Kenneth Hafner

New York State Public High School Athletic Association

November 1969

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New York State Public High School Athletic Association

NYSPHSAA

Albany, New York

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Football is a great game. It is great, in large measure, because of the interest in youngsters and their safety demonstrated by the hundreds of physicians, school administrators, athletic directors, coaches, trainers and just plain fans who contributed their time and effort in order to make this research effort possible.

TABLE OF CONTENTS

INTRODUCTION	1
Statement of the Problem	1
Review of the Literature	1
Objectives or Hypotheses	5
METHODS OR PROCEDURES	6
First Year - 1967-68	6
Subjects	7
Treatment	7
Instruments	7
Data Analysis	8
Second Year - 1968-69	8
Subjects	8
Treatment	9
Instruments	9
Data Analysis	12
RESULTS	12
First Year - 1967-68	12
Second Year - 1968-69	23
DISCUSSION	40
Implications of Findings	40
First Year - 1967-68	40
Second Year - 1968-69	40
IMPLICATIONS AND RECOMMENDATIONS	42
SUMMARY	44
REFERENCES	45

LIST OF TABLES

Table Number		Page
1	1967 - Number and % of Leg Injuries by Type of Cleat	13
2	1967 - Number and % of Total Leg Injuries by Heel and Degree of Seriousness	14
3	1967 - Number and % of Knee Injuries by Heel and Degree of Seriousness	15
4	1967 - Number and % of Ankle Injuries by Heel and Degree of Seriousness	16
5	1967 - Number and % of All Other Leg Injuries by Heel and Degree of Seriousness	17
6	1967 - Total Leg Injuries - Distribution by Degree of Seriousness and Equipment Worn	18
7	1967 - Knee Injuries - Distribution by Degree of Seriousness and Equipment Worn	19
8	1967 - Ankle Injuries - Distribution by Degree of Seriousness and Equipment Worn	20
9	1967 - Other Leg Injuries - Distribution by Degree of Seriousness and Equipment Worn	21
10	1967 - Serious (31+) Leg Injuries - Distribution by Degree of Seriousness and Equipment Worn	22
11	1968 - Total Leg Injuries by Shoe-Cleat-Support	24
12	1968 - Total Leg Injuries by Cleat	25
13	1968 - Knee Injuries by Shoe-Cleat-Support	26
14	1968 - Knee Injuries by Cleat	27
15	1968 - Serious Knee Injuries (31+) by Shoe-Cleat-Support	28

16	1968 - Serious Knee Injuries (31+) by Cleat	29
17	1968 - Serious Knee Injuries (31+) by Shoe-Cleat-Player Position	30
18	1968 - Serious Knee Injuries (31+) by Cleat-Player Position	31
19	1968 - Shoe-Cleat-Support of Players with History of Serious Knee Injury (31+) Compared to Total Player Population	32
20	1968 - Shoe-Cleat-Position of Players with History of Serious Knee Injury (31+) Compared to Total Player Population	33
21	1968 - Probability of Injury to the Lower Extremities	34
22	1968 - Multiple Regression Analysis - Selected Variables	39

INTRODUCTION

Statement of the Problem

Football, on an organized basis, is played in the United States by some 750,000 high school boys. In New York State alone, approximately 18,000 high school athletes engage in football competition at the varsity level each year.

Football is, at once, a spectacular and a violent game. In a sport characterized by maximal exertion and physical contact between individuals, injuries must be anticipated. And a variety of physical injuries are sustained by football players - injures which, in extreme cases, cause disability and, in the majority of instances, at least some loss of time from classroom instruction and athletic participation.

In 1963, the New York State Public High School Athletic Association initiated a series of studies directed to the identification (and eventual reduction) of the major causes of injury among interscholastic football players. This program, unparalleled in scope, was the first statewide survey in the nation designed to catalogue such injures, in a standardized and medically acceptable manner, by type and severity.

These earlier athletic injury studies, and the base line data derived therefrom, generated a major concern about the number and severity of (football) injuries to the lower extremities - by far the most common type of such accidents observed. Where possible, rules governing play and equipment used have been modified in the hope of providing greater levels of protection to participants. In some cases (mouth guards, for example) observation and logic provided sufficient grounds for adoption of modifications and a marked reduction in reported injuries followed. With regard to reducing injuries to the lower extremities, logic does not suffice and research, to date, has been extremely limited.

Review of the Literature

The research on athletic injuries in general and football injuries specifically is somewhat limited. A major portion of this thin literature base was found to be either clinically oriented or highly speculative. In some cases, the speculative output was based on limited, uncontrolled observations of small, often nonrepresentative populations. In other cases, the speculative output was purely hypothesis development.

Given these shortcomings, existing literature did give some direction to the present endeavor.

If football injuries are hazards to health, as suggested by Eastwood[1], then continuous research is necessary if the injury and fatality rate is to be reduced. Further, if sports injuries are to be prevented, Ryan[2] suggests that there must be an appreciation of what makes an injury in sports different from other injuries. The American Medical Association's publication Standard Nomenclature of Athletic Injuries[3] stated "there also must be an awareness that such injuries occur, have significance and merit faithful recording."

In a clinical and statistical study of football injuries at an overseas air force base, Allen[4] recorded 290 injuries sustained by 465 players during the course of 34 games in 1965 and 1966. Of these injuries, 111 were major football injuries. The knee was the most frequently injured area and sprains were the most frequent type of disabling injury. Thirty eight players were hospitalized, 22 players were operated upon and 65 players received injuries such that they were unable to finish out the season. There were no deaths.

These data would seem to be in general agreement with a statement by the American Medical Association's Committee on the Medical Aspects of Sports[5], which stated that the knee was the most frequently injured major joint of the body in athletes. These data are, however, in disagreement with a subsequent report by researchers at the University of Illinois[6], where ankle injuries were most frequent. However, both reports dealt with noncontact as well as contact sports.

Allen[7] concluded that the number of injuries resulting in disability were significant and attributable to (1) lack of medical supervision during preseason training periods and (2) limited preseason conditioning and practice sessions (due in part to the urgent nature of the military mission in Southeast Asia during the time of the study).

Rowe[8], interpreting data gathered by the New York State Public High School Athletic Association, put the problem of injuries to high school athletes into sharp focus. He reported that over a period of years (beginning in 1963) the incidence of injuries, by sport, in terms of 1,000 participant exposures revealed that football generated over five times the number of reportable injuries as the next highest sport, wrestling. With regard to severity of injuries sustained, in terms of the number of days lost from participation per 1,000 exposures, football generated a severity rate in excess of four times that of the next highest sport, soccer.

A strong case for the gathering and interpretation of athletic injury data was made by Morehouse and Rasch[9], who pointed out that such reports often lead to modifications of the rules, equipment and facilities

to increase safety. They expressed the belief that the continued occurrence of injuries places a heavy obligation on all individuals responsible for the welfare of the athlete.

One of the most comprehensive studies of athletic injuries was conducted at Harvard University between 1932 and 1954. Thorndike[10], reporting on the data, pointed to the knee as the most commonly injured major joint in athletes. Of some 7,394 reported injuries, 1,137 were to the athlete's knee. The large majority of athletic injury surveys substantiated this conclusion.

Concern for football injuries in general and for knee injuries in particular has been increasing in the past decade. The popularity of football and the high visibility accorded it by television has brought the problem of injuries and injury prevention to the fore in many circles, professional and lay. So much injury was done to the knee joint in 1968 that Lardner[11], writing in the New York Times, called it (1968) "The Year of the Knee."

The broad interest only recently focused on injuries to the lower extremities, particularly to the knee, has called attention to several small scale attempt to eliminate or decrease both the incidence and severity of such athletic injuries and has highlighted the speculative differences, as to cause and prevention, being discussed and examined by physicians and other professionals connected with athletics.

Knee injures, according to Gibbs[12], have been accepted traditionally as an occupational hazard of the football player. Hanley[13] supported that and reported his beliefs about the causes of knee injuries and the possible prevention of some knee injuries by means of shoe equipment modification.

Hanley[14] reported on statistics maintained at Bowdoin College since 1955 and highlighted the fact that four factors constitute the basic mechanism of a large proportion (77%) of knee injuries sustained by football players at his institution, namely (1) the foot of the injured extremity was fixed to the ground with long, conical cleats, (2) weight was borne on the extremity that was injured, (3) flexion of the knee, and (4) a torsional force was applied to the knee joint.

Of the four factors in the mechanism of knee injuries identified by Hanley[15], only one could be altered significantly--the "foot fixed to the ground" factor. Therefore, it was decided to remove the normal (2) heel cleats and replace them with 5/8" flat, rubber heels which would allow the player's foot to rotate. And this was all that was done at Bowdoin.

The next step taken at Bowdoin was to identify players with a history of knee injuries since they were most likely to suffer another similar injury. Since 1959, some 36 of these players were outfitted with shoes equipped with flat heels and short, broad soccer-type cleats on the sole. Of these players, identified as having a history of previous knee injuries, 35 have been able to play a complete football season even though 11 were observed to have been struck hard enough to reinjure the knee. The average time lost by these 11 players was 2.2 days while players not wearing heels and short front cleats averaged over 14 days of participation loss per injury.

Similar results have been reported (for players equipped with flat heels and/or short front cleats) by researchers at Colby College, Northeastern University, Harvard University, University of Houston (on Astro Turf), and other institutions.[16]

Rowe[17] reported the results of a numerically limited but concentrated study of 1,325 varsity football players from 44 high schools in the Rochester, New York area. His results indicated that the low-cut shoe with disc heel was the safest shoe-cleat combination of those studied. The Rochester area study concluded that the use of the low shoe, disc heel combination would, on the average, save each team two knee and ankle injuries per season when compared with the most dangerous equipment combination, the low shoe with conventional cleats. Data were equated to comparable hours of participation under practice and game conditions. No conclusions could be drawn as to the effect of any shoe-cleat combination in minimizing the severity of knee and ankle injuries.

A completely different point of view has been expressed by Pisani[18]. He stated that prior to inventing and producing modified footwear and variations in cleats, serious consideration would have to be given to authorities on the subject of knee injuries and to statistical analysis of such injuries. Simply stated

> The story unfolded by the computer and by the experience of men who play the game or coach it point away from the cleat story as the raison d'etre for knee injuries. Thorough questioning of the injured, review of motion pictures and stills, have failed to show a single, clearcut accident wherein the cleats were imbedded in the turf.

Pisani[19], Orthopedic Surgeon to the New York Football Giants, reported that the majority of knee injuries happened when the leg was in the "dry-twig" position while the player was at the bottom of a pileup.

He pointed out that, in his opinion, (a) the mechanics that produce (football) knee injuries are similar to those in any accident, varying only in proportion to the force generated, (b) the knee was not meant to withstand the extreme rigors of football, particularly because of its limitations in planes of motion, and (c) modified cleats or other variations in footwear play little or no part in the prevention of knee injuries.

The major conclusions generated by a review of the literature in this area are that (1) the high incidence of injuries to the lower extremities of football players has been thoroughly and consistently documented, (2) there are sharp differences in professional opinion as to the major causes of such injuries, and (3) there is a marked lack of research into the prevention or remediation of such injuries. In few cases was there real evidence of the employment of defensible research technique--sufficient numbers of subject, control or randomization of variables and the like.

Support for such a study was voiced by various legislative, medical, educational and athletic officials. Furthermore, the State Education Department, the Medical Society of the State of New York, and the Superintendents' Committee on Interscholastic Athletics requested the New York State Public High School Athletic Association to evaluate the potential of modified cleats in the prevention and/or remediation of football injuries to the lower extremities.

Objectives or Hypotheses

The first year of this two-year endeavor sought to attain objectives at several levels.

At one level, survey in nature and focused on outcome, the study sought data necessary to answering several basic questions, namely:

1. Does a modification of the type of cleats (alone) worn on football shoes bring about a reduction in the number of injuries to the leg area?

2. Does a modification of the type of cleats (alone) worn on football shoes bring about a reduction in the severity of injuries to the leg area?

3. Is there a combination of equipment factors--shoes, cleats, ankle treatments--which reduces the number of injuries to the leg area?

4. Is there a combination of equipment factors--shoes, cleats, ankle treatments--which reduces the severity of injuries to the leg area?

At a second level, one concerned more with process and procedure, the study sought to answer several global questions with longitudinal implications, namely:

1. What other factors associated with the game of football contribute to the occurrence of leg injuries?

2. What other factors associated with football players (the condition of the organism) contribute to the occurrence of leg injuries?

3. What type or types of techniques (survey, controlled--sampling versus total population--research, or clinical study) are most efficient in the study of athletic injuries?

In an importance sense, this endeavor sought to break virgin ground for future students and to provide a base line for the second year of this study.

The second year of this two-year study had several objectives, namely:

1. a replication of the first year of the study;

2. a refinement of the study from a survey approach (1967-68) to an experimental examination of the most pertinent variables associated with both the game of football (position of player, condition of the field, etc.) and with the player (conditioning, experience in sports, type and extent of injury, type of shoe equipment worn and the like);

3. an analysis of data generated in answer to the basic questions enumerated above;

4. the development of recommendations for the game of football and the equipping of its players; and

5. recommendations for further study.

METHODS OR PROCEDURES

First Year - 1967-68

The major objective of the first year of this study was the determination of the relative effect of modified shoe equipment (conventional, disc and shortie cleats) on the number and degree of severity of injuries

to the leg. Related to that goal, was a determination of optimum combinations of equipment (cleats, type of shoe, type of ankle support) for reduction of the number and severity of injuries to the lower extremity.

Subjects

A population of 17,777 varsity high school football players was examined during 1967-68, the first year of the study. This population represesented over 90% of such players in the State of New York and included almost all players from the Association of Private Schools of Metropolitan New York, New York State Association of Private Schools, N.Y. State Catholic High Schools Athletic Association, New York State Public High School Athletic Association, Public School Athletic League of the City of Buffalo and the Public School Athletic League of the City of New York.

Treatment

The major treatment variable was the type cleat worn by the various participants. Injury data--number of injuries and severity (in days removed from squad by physician)--were examined for the occurrence of significant deviation from expectation. Subsidiary comparisons were made by type of cleat, shoe and ankle treatment of those reported to have sustained injuries to the lower extremities.

Instruments

A data gathering instrument was designed and distributed to coaches in late Spring 1967. Information packets covering study goals, evaluative procedures and related data were prepared and disseminated. NYSPHSAA representatives met with coaches on a regional basis to clarify the research procedures and to discuss individual responsibilities.

The following types of information were gathered:

1. Basic information
   a. Total number of players on squad.
   b. Total leg injuries on squad.
   c. Number of players wearing conventional cleats.
   d. Number of players wearing conventional cleats injured in leg.
   e. Number of players wearing disc or flat heels.
   f. Number of players wearing disc or flat heels injured in leg.
   g. Number of players wearing shortie cleats.
   h. Number of players wearing shortie cleats injured in leg.

2. Information on specific injuries
   a. Name of injured player.
   b. Date of first practice session.
   c. Date of injury.
   d. Medical diagnosis.
   e. Severity of injury (days removed by physician).
      1) 1-7
      2) 8-14
      3) 15-30
      4) 31 or more
   f. History of previous injury.
   g. Activity when injury occurred.
      1) Blocking - Blocked
      2) Tackling - Tackled
      3) No contact
   h. Shoes
      1) High - Low
   i. Ankle support
      1) Wraps
      2) Tape
      3) No Treatment

Data Analysis

Accumulated data were cross-checked manually, keypunched, verified and transferred to tape. A variety of programs were developed to yield contingency tables. Contingency tables were examined for the presence or absence of trends indicating possible differences in the number and severity of leg-associated injuries by type of cleat alone and by type of shoe, cleat and ankle treatment.

A discussion of the decision to reject statistical treatments in the first year of the study appears in the following sections.

Second Year - 1968-69

The major objectives of the second year of the study were (1) the determination of the relative effect of type of shoe (high, low), type of cleat (conventional, disc, shortie), and type of ankle support (wrap, tape or none) on the number and degree of severity of football injuries to the lower extremity, and (2) the effect of other selected experimental variables (conditioning, experience in sports, condition of field, position of player, and previous history of severe injury) on injuries to the lower extremities.

Subjects

A population of 17,856 varsity high school football players was examined during 1968-69, the second year of the study. This population represented over 90% of such players in the State of New York and included most participants in all of the organized public and private school leagues in the State.

Treatment

The major treatment variables were the shoes, cleats and ankle supports worn by varsity high school football players during the course of the 1968 season. Subsidiary variables related either to the players or the conditions of the game of football, namely, conditioning, experience in sports, condition of field, position of player, activity (at time of injury) and previous history of serious injury to the lower extremities were also examined for relationship to the number and severity of injuries received during the course of play.

Instruments

The basic data gathering instrument employed in the first year of the study was modified and distributed to coaches and athletic directors during the late Spring and Summer of 1968. In addition, information packets were distributed and orientation sessions were held in each of the sections of the State in order to acquaint key personnel with the conditions of the study, research procedures and to discuss individual responsibilities.

The following types of information were gathered:

a. Experimental variables
   1. Conditioning
   2. Experience in sports
   3. Condition of field
   4. Position of player
   5. Severity of injury, including type and extent

b. Basic information
   1. Total number of players on squad by type of shoe equipment
   2. Total Number of injuries to the lower extremities by type of shoe equipment worn
   3. Name of player injured
   4. Date of first practice session
   5. Date of injury
   6. Notation of previous severe injury
   7. Activity when injury occurred (contact - non-contact)

Conditioning was measured on a two-point scale: participation by the individual (and his squad) in the experimental pre-season 5-10-5 conditioning program or participation in the normal program of physical conditioning which cannot begin until September first of any season.

Experience in Football was measured in terms of years of experience on school-sponsored teams, in grades 9-12.

Condition of Field was measured on a five-point, descriptive scale: soft soil (skin surface); hard soil (skin surface); short grass and/or thin grass; long grass and/or thick grass; Astroturf, Tartan turf or other man-made surface. This scale was established with the aid of specialists in Agronomy at the State University, technicians on the staff of the Suffolk County Agricultural Extension Service and head groundskeepers. A panel of football coaches and athletic directors were asked to review and comment upon the tentative scale. No modifications were suggested.

A committee of football coaches was empaneled to determine the most meaningful classification of players, by position. As a result of analyzing the unique requirements and exposures of participants, a six-position scale was established: offensive end; offensive interior line; offensive back; defensive end; defensive interior line; defensive back.

Injury classifications by area, type and degree of severity were developed by the physician-members of the Committee on the Medical Aspects of Sports of the New York State Medical Society. Nine area classifications were established: hip; groin; upper leg; knee; patella; menisci; lower leg; ankle; foot. Five classifications for type of injury were developed: fracture; sprain; contusion; bone chip; internal (including dislocation, separation and rupture). A four-point scale of seriousness of injury was developed: 1-7 days removed from participation by physician; 8-14 days restriction; 15-30 days removal; 31 or more days restriction. The number of days removed from football participation was considered to be objective given the conditions of this study.

During the Fall and Winter of 1968 the Athletic Association completed a study of the reliability of judgments obtained in diagnosing the severity of injury through the instrument developed for the purpose of gathering those and other data. These judgments were found to be of high reliability. It must be stated clearly, however, that the study of rater (judgmental) reliability had to be undertaken with a high degree of discretion and with several operative constraints.

First, it was not possible to assign independent physicians to (re)diagnose the type and severity of injuries certified by official team doctors. Early discussions of this type of reliability testing quickly raised questions of professional ethics on the part of participating and consulting physicians. Second, the type of judgment reliability testing required in this phase of the study did not lend itself to the statistical techniques commonly employed in determining the reliability and validity of

educational and psychological tests. (See, for example, the discussion in [illegible] and Ahmann, Statistical Methods in Educational and Psychological Research.)

All other data gathered during the course of the study were subjected to tests of reliability of varying types. For example:

(a) schools reporting participation in the experimental, extended physical conditioning program were checked against lists of schools approved for such participation by the State Education Department;

(b) reported data on experience (participation) in football in grades 9 through 12 were checked (on a sample basis) against individual student permanent records in 5% of the cases reported;

(c) a strong attempt to standardize and make reliable the reporting of field condition data was undertaken during the orientation meetings held in each Section during the preseason period. Several pieces of descriptive literature were mailed via the NYSPHSAA "Spot News" during the course of the football season;

(d) a 10% sample of reported positions of injured players was checked against team rosters. Furthermore, a fair cross-check was built into the data gathering instrument (and was related to the nature of the game). For example, since 99+% of players tackled are ball carriers and since backs and ends are the principal ball carriers, reporting errors (or seeming errors) were easily visible and subject to telephone verification;

(e) the data gathering instrument was designed to provide cross-checks on the reliability of the numerical data reported (for example, the data of injury and the date of medical approval to return should verify the degree of severity in days);

(f) several teams in each Section were spot-checked during the course of the season to verify the distribution of cleats, types of shoes and types of ankle treatments worn by players; and

(g) a 10% sample of previous injury notations were checked against school health and/or athletic department records.

It was determined that the data reported to the research team and included in the study were reliable to an extremely high degree. When the data were transferred to punched cards, mechanical and visual verification procedures were employed to insure reliability.

DATA ANALYSIS

Accumulated data were cross-checked manually, keypunched, verified and transferred to tape. A variety of computer programs were developed to (1) yield contingency tables for purposes of data inspection, (2) conduct an arcsine transformation on the data (players by equipment combinations worn) prior to testing the injury rate for significant departures from the population mean, and (3) conduct a stepwise multiple regression analysis of all leg injuries, all knee injuries and all ankle injuries for such variables (in order) as history or prior severe injury, number of games played, cleat, shoe, support, activity at of injury, position of player, conditioning, experience in sports.

RESULTS

First Year - 1967-68

Table 1 presents data on (a) the distribution of three types of cleat among the 17,777 players reported and (b) the occurrence of leg injuries to these players. In addition, Tables 2 through 5 present distributions of the number and percentage of leg injuries by degree of seriousness and type of cleat.

From a purely statistical point of view, the next step was the application of a Chi Square analysis of the data in Tables 1 through 5. Employing standard techniques for such analyses (see, for example, Wert, Neidt and Ahmann, Statistical Methods in Educational and Psychological Research or Edwards, Statistical Methods for the Behavioral Sciences), significant differences between expected and observed frequencies were found in Tables 1 and 2. In both instances, the contribution of the "shortie" cleats to the number of injuries defied chance (in Table 1 the difference could be attributable to chance less than once in one thousand times; in Table 2 less than 5 times in one hundred). Nonethless, under present circumstances, Chi Square was unacceptable as a statistical measure. The reasons for such rejection are obvious but will be covered in the next section (discussion).

Tables 6 through 9 present data on the distribution of the number of injuries by degree of seriousness among players wearing different equipment combinations (shoe, cleat, ankle treatment). Table 10 presents the distribution, by percentage, of the most serious total leg injuries among players wearing different equipment combinations. A trend showing the fewest serious leg injuries occurring among players wearing the low shoe, disc heel and either tape or wrapping (called treatment) on their ankles is obvious. This trend isequally visible when "total leg" is broken down into "knee," "ankle," and "other" areas of the leg. Table 10 summarizes and highlights previous tables.

TABLE 1

1967 NYSPHSAA Football Study
Number and % of Leg Injuries by Type of Cleat

Type of Heel	Players		Total Leg Injuries		Knee Injuries		Ankle Injuries		Other Leg Injuries	
	Number	%	Number	%	Number	%	Number	%	Number	%
Conventional	12,083	68.0	1,798	65.9	687	66.4	609	64.5	502	65.6
Disc	5,034	28.3	795	29.1	304	29.4	276	30.7	215	28.1
Shortie	660	3.7	137	5.0	44	4.2	45	4.8	48	6.3
TOTAL	17,777	100.0	2,730	100.0	1,035	100.0	930	100.0	765	100.0

TABLE 2

1967 NYSPHSAA Football Study
Number and % of Total Leg Injuries by Heel and Degree of Seriousness

Seriousness	CONVENTIONAL Number of Injuries	%	DISC Number of Injuries	%	SHORTIE Number of Injuries	%
1 - 7 Days	852	47.9	399	50.0	80	59.6
8 - 14 Days	344	19.3	165	20.7	13	9.7
15 - 30 Days	209	11.8	82	10.3	19	14.2
30+ Days	374	21.0	152	19.0	22	16.5
TOTAL	1,779	100.0	798	100.0	134	100.0

TABLE 3

1967 NYSPHSAA Football Study
Number and % of Knee Injuries by Heel and Degree of Seriousness

Seriousness	CONVENTIONAL Number of Injuries	%	DISC Number of Injuries	%	SHORTIE Number of Injuries	%
1 - 7 Days	261	37.9	119	39.2	23	52.2
8 - 14 Days	159	23.2	67	22.0	3	6.8
15 - 30 Days	84	12.2	41	13.5	9	20.5
30+ Days	183	26.7	77	25.3	9	20.5
TOTAL	687	100.0	304	100.0	44	100.0

TABLE 4

1967 NYSPHSAA Football Study
Number and % of Ankle Injuries by Heel and Degree of Seriousness

Seriousness	CONVENTIONAL Number of Injuries	%	DISC Number of Injuries	%	SHORTIE Number of Injuries	%
1 - 7 Days	326	53.5	145	52.5	33	73.4
8 - 14 Days	117	19.2	66	23.9	7	15.5
15 - 30 Days	74	12.2	27	9.8	4	8.9
30+ Days	92	15.1	38	13.8	1	2.2
TOTAL	609	100.0	276	100.0	45	100.0

TABLE 5

1967 NYSPHSAA Football Study
Number and % of All Other Leg Injuries by Heel and Degree of Seriousness

Seriousness	CONVENTIONAL Number of Injuries	%	DISC Number of Injuries	%	SHORTIE Number of Injuries	%
1 - 7 Days	265	54.9	135	61.9	24	53.3
8 - 14 Days	68	14.1	32	14.7	3	6.7
15 - 30 Days	51	10.6	14	6.4	6	13.4
30+ Days	99	20.4	37	17.0	12	26.6
TOTAL	483	100.0	218	100.0	45	100.0

TABLE 6

Total Leg Injuries
Distribution by Degree of Seriousness and Equipment Worn
1967 NYSPHSAA Football Study

(HEEL - SHOE - SUPPORT)

Type Cleats / CONVENTIONAL HEEL	Participants 12,083											
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	217	46.07	185	50.68	102	46.15	112	48.70	69	47.92	156	48.60
8-14	90	19.11	72	19.73	55	24.89	38	16.52	27	18.75	60	18.69
15-30	63	13.38	38	10.41	22	9.95	27	11.74	15	10.42	39	12.15
↓ 31 Plus	101	21.44	70	19.81	42	19.00	53	23.04	33	22.91	66	20.56
TOTAL INJURIES	471		365		221		230		144		321	

Type Cleats / DISC HEEL	Participants 5,034											
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	74	44.85	88	50.29	40	45.98	59	55.66	43	50.58	89	54.60
8-14	37	22.42	34	19.43	15	17.24	25	23.59	15	17.65	37	22.70
15-30	17	10.30	23	13.14	8	9.19	10	9.43	8	9.41	16	9.82
↓ 31 Plus	37	22.43	30	17.14	24	27.59	12	11.32	19	22.35	21	12.88
TOTAL INJURIES	165		175		87		106		85		163	

Type Cleats / SHORTIE HEEL	Participants 660											
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	7	58.33	32	56.14	12	75.00	9	50.00	1	33.33	16	72.72
8-14	0	.00	5	8.77	0	.00	4	22.22	0	.00	3	13.64
15-30	3	25.00	9	15.79	3	18.75	2	11.11	1	33.33	0	.00
↓ 31 Plus	2	16.67	11	19.30	1	6.25	3	16.67	1	33.33	3	13.64
TOTAL INJURIES	12		57		16		18		3		22	

TABLE 7
Knee Injuries
Distribution by Degree of Seriousness and Equipment Worn
1967 NYSPHSAA Football Study

(HEEL - SHOE - SUPPORT)

Type Cleats CONVENTIONAL HEEL — Participants 12,083												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	71	38.38	50	40.32	32	35.16	38	41.76	23	37.71	42	35.30
8-14	46	24.86	30	24.19	27	29.67	14	15.38	12	19.67	28	23.53
15-30	23	12.43	18	14.52	11	12.09	12	13.19	8	13.11	8	6.72
↓ 31 Plus	45	24.33	26	20.97	21	23.08	27	29.67	18	29.51	41	34.45
TOTAL INJURIES	185		124		91		91		61		119	

Type Cleats DISC HEELS — Participants 5,034												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	28	44.44	28	37.84	13	33.33	15	39.47	10	35.71	22	39.29
8-14	10	15.88	16	21.62	9	23.08	12	31.58	4	14.29	15	26.78
15-30	8	12.70	12	16.22	3	7.69	5	13.16	5	17.86	8	14.29
↓ 31 Plus	17	26.98	18	24.32	14	35.90	6	15.79	9	32.14	11	19.64
TOTAL INJURIES	63		74		39		38		28		56	

Type Cleats SHORTIE HEEL — Participants 660												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	3	50.00	6	40.00	6	66.67	2	40.00	0	.00	5	83.33
8-14	0	.00	2	13.33	0	.00	1	20.00	0	.00	0	.00
15-30	2	33.33	4	26.67	2	22.22	0	.00	1	100.00	0	.00
↓ 31 Plus	1	16.67	3	20.00	1	11.11	2	40.00	0	.00	1	16.67
TOTAL INJURIES	6		15		9		5		1		6	

TABLE 8

Ankle Injuries

Distribution by Degree of Seriousness and Equipment Worn

1967 NYSPHSAA Football Study

(HEEL - SHOE - SUPPORT)

Type Cleats / CONVENTIONAL HEEL	Participants 12,083													
SHOE →		HIGH		LOW		HIGH		LOW		HIGH		LOW		
FACTORS →		No Support				Wraps				Tape				
DEGREE 1-7		77	47.23	79	58.52	28	45.16	43	58.90	25	58.14	73	56.59	
↓	8-14	29	17.79	22	16.30	18	29.03	13	17.81	10	23.25	25	19.38	
↓	15-30	28	17.18	12	8.88	7	11.29	5	6.85	3	6.98	18	13.95	
↓	31 Plus	29	17.79	22	16.30	9	14.52	12	16.44	5	11.63	13	10.08	
TOTAL INJURIES		163		135		62		73		43		129		
Type Cleats / DISC HEEL	Participants 5,034													
SHOE →		HIGH		LOW		HIGH		LOW		HIGH		LOW		
FACTORS →		No Support				Wraps				Tape				
DEGREE 1-7		16	33.33	30	53.57	14	56.00	26	61.91	20	54.05	38	60.31	
↓	8-14	19	39.35	10	17.86	2	8.00	8	19.05	11	29.73	15	23.81	
↓	15-30	5	10.42	8	14.28	3	12.00	4	9.52	2	5.41	5	7.49	
↓	31 Plus	8	16.67	8	14.28	6	24.00	4	9.52	4	10.81	5	7.49	
TOTAL INJURIES		48		56		25		42		37		63		
Type Cleats / SHORTIE HEEL	Participants 660													
SHOE →		HIGH		LOW		HIGH		LOW		HIGH		LOW		
FACTORS →			No Support				Wraps				Tape			
DEGREE 1-7		4	80.00	12	70.59	4	100.00	4	57.14	1	100.00	7	77.78	
↓	8-14	0	.00	2	11.76	0	.00	2	28.57	0	.00	2	22.22	
↓	15-30	1	20.00	2	11.76	0	.00	1	14.29	0	.00	0	.00	
↓	31 Plus	0	.00	1	5.85	0	.00	0	.00	0	.00	0	.00	
TOTAL INJURIES		5		17		4		7		1		9		

TABLE 9

"Other" Leg Injuries
Distribution by Degree of Seriousness and Equipment Worn
1967 NYSPHSAA Football Study

(HEEL - SHOE - SUPPORT)

Type Cleats / Participants												
CONVENTIONAL HEEL — 12,083												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	69	56.1	56	52.8	42	61.8	31	47.0	21	52.5	41	56.2
8-14	15	12.2	20	18.9	10	14.7	11	16.7	5	12.5	7	9.6
15-30	12	9.8	8	7.5	4	5.9	10	15.2	4	10.0	13	17.8
↓ 31 Plus	27	21.9	22	20.8	12	17.6	14	22.1	10	25.0	12	16.4
TOTAL INJURIES	123		106		68		66		40		73	
Type Cleats / Participants												
DISC HEEL — 5,034												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	30	55.6	30	66.7	13	56.5	18	69.2	13	65.0	29	68.2
8-14	8	14.8	8	17.8	4	17.4	5	19.2	0	0	7	15.9
15-30	4	7.4	3	6.7	2	8.7	1	3.8	1	5.0	3	6.8
↓ 31 Plus	12	22.2	4	8.8	4	17.4	2	7.8	6	30.0	5	9.1
TOTAL INJURIES	54		45		23		26		20		44	
Type Cleats / Participants												
SHORTIE HEEL — 660												
SHOE →	HIGH		LOW		HIGH		LOW		HIGH		LOW	
FACTORS →	No Support				Wraps				Tape			
DEGREE 1-7	0	0.	14	56.0	2	66.7	3	50.0	0	0.	4	57.1
8-14	0	0.	1	4.0	0	0.	1	16.7	0	0.	1	14.3
15-30	0	0.	3	12.0	1	33.3	1	16.7	0	0.	0	0.
↓ 31 Plus	1	100.00	7	28.0	0	0.	1	16.7	1	100.0	2	28.6
TOTAL INJURIES	1		25		3		6		1		7	

TABLE 10

Serious (31+) Leg Injuries
Distribution by Area. and Equipment Worn
1967 NYSPHSAA Football Study

THE AREA	TYPE SHOE	TYPE HEEL CLEAT	NO ANKLE SUPPORT	WEARING ANKLE WRAPS	WEARING ANKLE TAPE
(1) THE TOTAL LEG	HIGH	CONV.	21.44	19.0	22.91
	LOW	CONV.	19.18	23.04	20.56
	HIGH	DISC	22.43	27.59	22.35
	LOW	DISC	17.14	11.32	12.88
(2) KNEE	HIGH	CONV.	24.33	23.08	29.51
	LOW	CONV.	20.97	29.67	34.45
	HIGH	DISC	26.98	35.90	32.14
	LOW	DISC	24.32	15.79	19.64
(3) ANKLE	HIGH	CONV.	17.79	14.52	11.63
	LOW	CONV.	16.30	16.44	10.08
	HIGH	DISC	16.67	24.00	10.81
	LOW	DISC	14.28	9.52	7.94
(4) OTHER AREAS OF THE LEG	HIGH	CONV.	21.9	17.6	25.0
	LOW	CONV.	20.8	22.1	16.4
	HIGH	DISC	22.2	17.4	30.0
	LOW	DISC	8.8	7.8	9.1

Best results at 31 Plus Level achieved with the combination of:
Low shoe, Disc type heel cleat, ankles taped or wrapped.

Second Year - 1968-1969

For the basic comparisons of injury rate with exposure (to injury), the exposure was defined as the proportion of varsity high school football players in the state who were wearing the equipment combinations being examined. This exposure was considered as a population mean to which the proportion of injuries in that equipment category was compared. Since the proportions were generally less than .10, an arcsine transformation was employed on the data prior to testing the injury rate for significant departures from the population mean.

The following assumptions were made in applying the significance tests to the data:

1. The sample size was equal to the number of injuries in the population of players;

2. The proportion of injuries in each equipment category was assumed to be randomly distributed about the population mean (exposure in the equipment category); and

3. If the proportion of injuries in the equipment category was more than 1.96 standard errors above or below the mean proportion, it was considered a significant departure.

This comparison was made for (1) all leg injuries for eighteen shoe-cleat-support categories, (2) all leg injuries for three cleat categories, (3) all knee injuries for eighteen shoe-cleat-support categories, (4) all knee injuries for three cleat categories, (5) serious (31+ day) knee injuries for eighteen shoe-cleat-support categories, (6) serious (31+ day) knee injuries for three cleat categories, (7) serious (31+ day) knee injuries for eighteen shoe-cleat-player position categories, (8) serious (31+ day) knee injuries for nine cleat-player position categories.

In addition, the proportion of players with a history of previous severe knee injury (31+ day) was compared with the population proportion in each of eighteen equipment categories and in each of eighteen shoe-cleat-player position categories. The intent was to determine selective usage of equipment with football players having a history of prior severe knee injury.

TABLE 11

1968 NYSPHSAA Football Study

Total Leg Injuries by Shoe-Cleat-Support

			High Shoe				Low Shoe			
			N	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats	Wrap -	Exposure -	1,527	.086	.591	*(+)	1,794	.100	.644	
		Injuries -	201	.068	.535		297	.102	.644	
	Tape -	Exposure -	989	.055	.495	*(+)	1,620	.091	.609	*(-)
		Injuries -	129	.044	.423		329	.113	.676	
	None -	Exposure -	2,630	.147	.795	*(+)	2,366	.132	.738	*(-)
		Injuries -	331	.113	.676		442	.151	.795	
Disc Heel	Wrap -	Exposure -	569	.031	.354	*(+)	1,018	.057	.495	*(-)
		Injuries -	73	.025	.318		137	.047	.437	
	Tape -	Exposure -	373	.021	.291		1,078	.060	.495	*(-)
		Injuries	60	.020	.284		228	.078	.574	
	None -	Exposure -	1,076	.060	.495		1,203	.067	.534	
		Injuries -	179	.061	.495		221	.076	.534	
Shortie Cleats	Wrap -	Exposure -	104	.006	.155		272	.015	.246	
		Injuries -	22	.008	.179		56	.019	.277	
	Tape-	Exposure -	49	.003	.090	*(-)	355	.020	.284	
		Injuries -	20	.007	.168		56	.019	.277	
	None	Exposure -	192	.011	.210	*(+)	641	.036	.382	
		Injuries -	20	.007	.168		116	.040	.402	
TOTAL		Exposure -	17,856							
		Injuries	2,917							

* Critical Difference = .036

TABLE 12
1968 NYSPHSAA Football Study
Total Leg Injuries by Cleat

		N	p	Ø	Sig.
Conventional Cleats	Exposure	10,926	.612	1.793	*(+)
	Injuries	1,729	.593	1.751	
Disc Heel	Exposure	5,317	.298	1.159	
	Injuries	898	.308	1.181	
Shortie Cleats	Exposure	1,613	.090	.609	
	Injuries	290	.101	.643	
TOTAL	Exposure	17,856			
	Injuries	2,917			

* Critical Difference = .036

TABLE 13
1968 NYSPHSAA Football Study
Knee Injuries by Shoe-Cleat-Support

			High Shoe				Low Shoe			
			N	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats	Wrap	Exposure	1,527	.086	.591	*(+)	1,794	.100	.644	
		Injuries	45	.039	.398		100	.087	.609	
	Tape	Exposure	989	.055	.495		1,620	.091	.609	
		Injuries	80	.069	.535		153	.132	.738	
	None	Exposure	2,630	.147	.795	*(+)	2,366	.132	.738	
		Injuries	139	.120	.708		164	.141	.767	
Disc Heel	Wrap	Exposure	569	.031	.354		1,018	.057	.495	*(+)
		Injuries	43	.037	.387		52	.045	.428	
	Tape	Exposure	373	.021	.291		1,078	.060	.495	
		Injuries	29	.025	.318		85	.073	.535	
	None	Exposure	1,076	.060	.495		1,203	.067	.534	
		Injuries	78	.067	.535		80	.069	.535	
Shortie Cleats	Wrap	Exposure	104	.006	.155		272	.015	.246	
		Injuries	12	.010	.200		26	.022	.298	
	Tape	Exposure	49	.003	.090		355	.020	.284	
		Injuries	6	.005	.142		25	.022	.298	
	None	Exposure	192	.011	.210		641	.036	.382	
		Injuries	7	.006	.155		38	.033	.365	
TOTAL		Exposure	17,856							
		Injuries	1,162							

* Critical Difference = .0575

TABLE 14
1968 NYSPHSAA Football Study
Knee Injuries by Cleat

		N	p	Ø	Sig.
Conventional Cleats -	Exposure -	10,926	.612	1.793	
	Injuries -	681	.586	1.752	
Disc Heel -	Exposure -	5,317	.298	1.159	
	Injuries -	367	.316	1.202	
Shortie Cleats -	Exposure -	1,613	.090	.609	
	Injuries	114	.098	.644	
TOTAL	Exposure -	17,856			
	Injuries	1,162			

* Critical Difference = .0575

TABLE 15
1968 NYSPHSAA Football Study
Serious Knee Injuries (31+) by Shoe-Cleat-Support

			High Shoe				Low Shoe			
			N	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats -	Wrap -	Exposure -	1,527	.086	.591		1,794	.100	.644	
		Injuries -	31	.094	.609		32	.097	.644	
	Tape -	Exposure -	989	.055	.495		1,620	.091	.609	*(-)
		Injuries -	15	.045	.428		44	.134	.738	
	None -	Exposure -	2,630	.147	.795		2,366	.132	.738	
		Injuries -	42	.128	.738		46	.140	.767	
Disc Heel -	Wrap -	Exposure -	569	.031	.354		1,018	.057	.495	*(+)
		Injuries -	11	.033	.365		11	.033	.365	
	Tape -	Exposure -	373	.021	.291		1,078	.060	.495	
		Injuries -	9	.027	.330		25	.076	.574	
	None -	Exposure -	1,076	.060	.495		1,203	.067	.534	
		Injuries -	13	.040	.403		27	.082	.574	
Shortie Cleats -	Wrap -	Exposure -	104	.006	.155		272	.015	.246	
		Injuries -	3	.009	.190		5	.015	.246	
	Tape -	Exposure -	49	.003	.090		355	.020	.284	
		Injuries -	1	.003	.110		7	.021	.291	
	None -	Exposure -	192	.011	.210		641	.036	.382	*(+)
		Injuries -	1	.003	.110		5	.015	.246	
TOTAL		Exposure -	17,856							
		Injuries -	328							

* Critical Difference = .108

TABLE 16
1968 NYSPHSAA Football Study
Serious Knee Injuries (31+) by Cleat

		N	p	Ø	Sig.
Conventional Cleats	Exposure -	10,926	.612	1.792	
	Injuries -	210	.640	1.854	
Disc Heel	Exposure -	5,317	.298	1.159	
	Injuries -	96	.292	1.137	
Shortie Cleats	Exposure -	1,613	.090	.609	
	Injuries -	22	.067	.536	
TOTAL	Exposure -	17,856			
	Injuries -	328			

* Critical Difference = .108

TABLE 17
1968 NYSPHSAA Football Study
Serious Knee Injuries (31+) by Shoe-Cleat-Player Position

			High Shoe				Low Shoe			
			N	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats -	Ends	Exposure -	643	.036	.382	*(-)	1,245	.069	.536	
		Injuries -	20	.061	.495		16	.049	.446	
	Linemen	Exposure -	3,826	.214	.952	*(+)	2,160	.121	.708	
		Injuries -	51	.154	.795		41	.121	.708	
	Backs	Exposure -	673	.038	.392		2,340	.131	.738	*(-)
		Injuries -	17	.055	.471		65	.197	.927	
Disc Heels -	Ends	Exposure -	307	.017	.261		715	.040	.403	*(+)
		Injuries -	3	.009	.190		7	.021	.291	
	Linemen	Exposure -	1,266	.071	.536		910	.051	.451	
		Injuries -	21	.064	.495		16	.049	.446	
	Backs	Exposure -	447	.025	.318		1,716	.096	.644	
		Injuries -	9	.026	.324		42	.127	.738	
Shortie Cleats -	Ends	Exposure -	35	.002	.090		240	.013	.229	
		Injuries -	1	.003	.110		6	.017	.261	
	Linemen	Exposure -	267	.015	.246		485	.027	.330	*(+)
		Injuries -	3	.009	.190		3	.009	.190	
	Backs	Exposure -	45	.002	.090		520	.029	.342	
		Injuries -	1	.003	.110		8	.024	.311	
	TOTAL	Exposure -	17,840							
		Injuries -	330							

* Critical Difference = .108

TABLE 18
1968 NYSPHSAA Football Study
Serious Knee Injuries (31+) by Cleat-Player Position

			N	p	Ø	Sig.
Conventional Cleats -	Ends -	Exposure -	1,888	.106	.676	
		Injuries -	36	.109	.676	
	Linemen -	Exposure -	5,986	.335	1.224	*(+)
		Injuries -	92	.279	1.115	
	Backs -	Exposure -	3,013	.169	.823	*(-)
		Injuries -	82	.248	1.047	
Disc Heels -	Ends -	Exposure -	1,022	.057	.495	*(+)
		Injuries -	10	.030	.348	
	Linemen -	Exposure -	2,176	.122	.708	
		Injuries -	37	.112	.676	
	Backs -	Exposure -	2,163	.121	.708	
		Injuries -	51	.154	.795	
Shortie Cleats -	Ends -	Exposure -	275	.015	.246	
		Injuries -	7	.021	.291	
	Linemen -	Exposure -	752	.042	.413	*(+)
		Injuries -	6	.018	.269	
	Backs -	Exposure -	565	.032	.360	
		Injuries -	9	.027	.330	
TOTAL		Exposure -	17,840			
		Injuries -	330			

* Critical Difference = .108

TABLE 19
1968 NYSPHSAA Football Study
Shoe-Cleat-Support of Players with History of Serious Knee Injury (31+) Compared to Total Player Population

			High Shoe				Low Shoe			
			N,	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats -	Wrap -	Population -	1,527	.086	.591		1,794	.100	.644	*(+)
		History -	14	.069	.535		10	.049	.446	
	Tape -	Population -	989	.055	.495		1,620	.091	.609	
		History -	10	.049	.446		21	.103	.644	
	None -	Population -	2,630	.147	.795	*(+)	2,366	.132	.738	*(+)
		History -	18	.083	.574		15	.073	.536	
Disc Heels -	Wrap -	Population -	569	.031	.354		1,018	.057	.495	
		History -	9	.044	.423		14	.069	.535	
	Tape -	Population -	373	.021	.291	*(-)	1,078	.060	.495	*(-)
		History -	17	.083	.574		39	.191	.902	
	None -	Population -	1,076	.060	.495		1,203	.067	.534	
		History -	9	.049	.446		12	.059	.494	
Shortie Cleats -	Wrap -	Population -	104	.006	.155		272	.015	.246	
		History -	2	.010	.200		1	.005	.142	
	Tape -	Population -	49	.003	.090	*(-)	355	.020	.284	
		History -	5	.025	.318		3	.015	.246	
	None -	Population -	192	.011	.210		641	.036	.382	
		History -	1	.005	.142		4	.020	.284	
TOTAL -		Population -	17,856							
		History -	204							

* Critical Difference = .137

TABLE 20

1968 NYSPHSAA Football Study

Shoe-Cleat-Position of Players with History of Serious Knee Injury (31+) Compared to Total Player Population

			High Shoe				Low Shoe			
			N	p	Ø	Sig.	N	p	Ø	Sig.
Conventional Cleats -	Ends -	Population -	643	.036	.382		1,245	.069	.536	
		History -	8	.039	.398		13	.063	.515	
	Linemen -	Population -	3,826	.214	.952	*(+)	2,160	.121	.708	*(+)
		History -	28	.136	.752		10	.058	.495	
	Backs -	Population -	673	.038	.392		2,340	.131	.738	
		History -	6	.029	.342		23	.112	.676	
Disc Heels -	Ends -	Population -	307	.017	.261		715	.040	.403	
		History -	4	.019	.277		7	.033	.365	
	Linemen -	Population -	1,266	.071	.536	*(-)	910	.051	.451	*(-)
		History -	27	.131	.738		18	.087	.609	
	Backs -	Population -	447	.025	.381		1,716	.096	.644	*(+)
		History -	4	.019	.277		40	.194	.276	
Shortie Cleats -	Ends -	Population -	35	.002	.090		240	.013	.229	
		History -	2	.010	.200		4	.019	.277	
	Linemen	Population -	267	.015	.246		485	.027	.330	
		History -	4	.019	.277		2	.010	.200	
	Backs -	Population -	45	.002	.090		520	.029	.342	*(+)
		History -	2	.010	.200		2	.010	.200	
	TOTAL	Population -	17,856							
		History -	204							

* Critical Difference = .137

TABLE 21
1968 NYSPHSAA Football Study
Probability of Injury to the Lower Extremities

Type of Injury	Population	Number of Injuries	Probability
Reportable Injury of Lower Extremity (one or more days removed from participation by physician)	17,856	2,917	16.4/100
Reportable Knee Injury (one or more days removed from participation by physician)	17,856	1,162	6.5/100
Serious Knee Injury (31+ days removed from participation by physician)			
All Players	17,856	328	1.8/100
Players with No Previous History	17,652	274	1.6/100
Players with Previous History	204	54	26.5/100

Table 11 presents data on the total number of reportable leg injuries (by type of shoe, cleat and ankle support) sustained by varsity high school football players during the 1968 season. By means of an arcsine transformation these data were compared to the proportion of the total population (exposure) similarly equipped. Significant deviations from expectation were observed as follows:

Fewer injuries than expected - high shoe, conventional cleat, wrap
high shoe, conventional cleat, tape
high shoe, conventional cleat, none
high shoe, disc heel, wrap
high shoe, shortie cleats, none
low shoe, disc heel, wrap

More injuries than expected - high shoe, shortie cleats, tape
low shoe, conventional cleats, tape
low shoe, conventional cleats, none
low shoe, disc heel, tape

Table 12 indicates clearly that where cleats alone were considered, players equipped with conventional cleats were injured in the lower extremities at a rate significantly less than expected. Leg injuries sustained by players equipped with disc heels or shortie cleats were at an expected rate when compared to exposures.

Table 13 presents data on the total number of reportable knee injuries (by type of shoe, cleat and ankle support) sustained by players during the 1968 season. Significant deviations from expectation were observed as follows:

Fewer injuries than expected - high shoe, conventional cleats, wrap
high shoe, conventional cleats, none
low shoe, disc heel, wrap

Table 14 indicates that when cleats alone were considered, all players sustained reportable knee injuries at a rate consonant with exposure.

Table 15 presents data on the total number of serious (31 or more days removed from participation by a physician) knee injuries (by type of shoe, cleat and ankle support) sustained by varsity high school football players during the 1968 season. By means of an arcsine transformation these data were compared to the proportion of the total population (exposure) similarly equipped. Significant deviations from expectation were observed as follows:

Fewer injuries than expected - low shoe, disc heel, wrap
low shoe, shortie cleats, none

More injuries than expected - low shoe, conventional cleats, tape

Table 16 indicates that where cleats alone were considered, all players sustained serious knee injuries at a rate consonant with exposure.

Table 17 presents data on the total number of serious knee injuries (by type of shoe, cleat and player position) sustained by varsity high school football players during the 1968 season. By means of an arcsine transformation these data were compared to the proportion of the total population (exposure) similarly equipped and assigned. Significant deviations from expectation were observed as follows:

Fewer injuries than expected - high shoe, conventional cleats (linemen)
low shoe, disc heel (ends)
low shoe, shortie cleats (lineman)

More injuries than expected - high shoes, conventional cleats (ends)
low shoes, conventional cleats (backs)

Table 18 indicates that when cleats assigned by player position were considered (excluding shoe and ankle treatment), significant deviations from expectation were observed as follows:

Fewer injuries than expected - conventional cleats (linemen)
disc heels (ends)
shortie cleats (linemen)

More injuries than expected - conventional cleats (backs)

Since one of the thrusts of the present study was to discover the incidence of knee (re) injury of varsity high school football players with a history of prior serious (31 days or more removed from participation by a physician) knee injury, three analyses were made, including (a) shoe-cleat-ankle support of players with a history of serious knee injury compared to equipment distribution in the total player population, (b) shoe-cleat-position of players with a history of serious knee injury compared to the total player population, and (c) probability in injury to the lower extremities, with particular reference to serious knee injury and reinjury.

Table 19 presents the shoe, cleat, ankle support of players with a history of prior serious (31+) knee injury compared to the distribution of those factors in the total player population. Significant deviations from expectation were as follows:

Lower assignment rate than expected - high shoe, conventional cleats, none
low shoe, conventional cleats, wrap
low shoe, conventional cleats, none

Higher assignment rate than expected- high shoe, disc heels, tape
high shoe, shortie cleats, tape
low shoe, disc heels, tape

Table 20 presents the shoe, cleat, player position of players with a history of prior serious (31+) knee injury compared to the total player population. Significant deviations from expectation were as follows:

Lower assignment rate than expected - high shoe, conventional cleats, (linemen)
low shoe, conventional cleats (linemen)
low shoe, disc heels (backs)
low shoe, shortie cleats (backs)

Higher assignment rate than expected- high shoe, disc heels (linemen)
low shoe, disc heels (linemen)

Table 21 portrays clearly the probability of injury to the lower extremities, injury to the knee, serious injury to the knee, and serious reinjury to the knee. The most significant fact is the extremely high probability of serious reinjury to the knees of players with a previous history of serious knee injury (15 to 17 times as likely to occur than to players with no previous history).

A stepwise multiple regression analysis was performed with selected variables to predict he degree of seriousness of injuries to the lower extremities of varsity high school football players during the 1968 season. The variables which were continuous or which implied an underlying continuum were employed as raw values. These variables were number of games played and years of experience in sports. The categorical variables were coded as dummy variables to indicate group membership as suggested by Cohen[20]. These variables were history of previous injury (1), cleat type (2), shoe type (1), ankle support (2), action at time of injury (4), position played (5), pre-conditioning (1).

In all, the dummy coding generated sixteen variables for the regression analysis. The order of selection of the variables was arbitrarily determined from knowledge of prior findings and the considered judgment of the investigators. The order of selection was history of

prior injury, number of games, cleat type, shoe type, ankle support, position of player, pre-conditioning, years of experience in sports. The basic concept in this analysis was that the addition of information from each of the categories of variables would increase the predictability, or relationship with the continuum of seriousness. The increase in the multiple R as each variable was added to the regression seen in Table 22, where the successive values of R are presented.

In general, the relationship was very low even when all eighteen variables were included in the regression. For the "all leg injuries" regression, only approximately 5 per cent of the variance in seriousness was explained by the eighteen variables. For "all knee injuries," only 9 per cent of the variance in seriousness was explained by the factors under examination.

Although different orders for the addition of variables to the multiple regression might result in significant increases at different phases of the analysis, the total explained variance would remain constant.

TABLE 22
1968 NYSPHSAA Football Study
Multiple Regression Analysis--Selected Variables

Variables	All Leg Injuries		All Knee Injuries	
	R	Significance of Increase	R	Significance of Increase
History of Prior Injury	.150	*	.133	*
Number of Games	.152	N.S.	.134	N.S.
Type of Cleat	.165	*	.138	N.S.
Type of Shoe	.165	N.S.	.154	N.S.
Type of Ankle Support	.167	N.S.	.163	N.S.
Action	.194	N.S.	.178	N.S.
Position of Player	.197	N.S.	.218	N.S.
Conditioning	.197	N.S.	.222	N.S.
Experience in Sports	.222	*	.303	*

DISCUSSION

Implications of Findings

First Year - 1967-68

Because of the relatively uncontrolled nature of the study (survey) in its first year, only the seeming trend toward the reduction in severity of leg injuries associated with football players who wore a combination of low shoes, disc heels and either tape or wrap ankle supports can be discussed with any degree of certitude. The basic assumption of the study staff was that players will be injured and that data can be gathered in a uniform manner and employed to cast some light on related factors.

The restriction of the study to "injured" (only) created basic problems of applicability to the total population of players. Conclusions drawn from simple significance tests were not especially useful to either the investigators or the field. For example, the computation of Chi Square for contingency tables where N was very large presented well-known problems of statistical significance as contrasted with meaningfulness of data. Table 1 illustrated the point. The large majority of operative variables - equipment, number of games, condition of player - were uncontrolled. While one may assume randomization of these (and other) variables because of sample size (17,777 players), the distribution of cleats by type - also uncontrolled - into such unequal proportions (conventional - 12,083, disc - 5,034, shortie - 660) rendered the assumption asunder in its specific application. It was obvious, for example, that injuries to players wearing shortie cleats were disproportionally high but inability to assume randomization of all other variables among only 660 players clouded the finding.

The first year of the study, 1967-68, while it generated a wealth of data, had a philosophical rather than a research goal as a primary objective. Simply stated, the goal was to develop a rational scheme for statistically treating and interpreting such data as a year of preliminary exploration might point to as vital. And this year of study laid the foundation for the second and final year of the study.

Second Year - 1968-69

Analysis of injury rates as related to the type of cleats (alone) worn by varsity high school players during the 1968 season produced somewhat mixed results. In terms of all reportable injuries to the lower extremities (Table 12), players equipped with conventional cleats were injured at a rate significantly lower than expectation. However, when the investigators analyzed sub-areas of injury (for example, knee injuries and serious knee injuries - Tables 14 and 16) by cleat alone, no deviations from expectation were observed.

Additional data gathered in 1968-69 made it possible to carry the analysis of the effect of equipment to a further refinement which included not only cleats worn but also type of shoe and type of ankle support. With regard to the total number of reportable injuries to the lower extremities (Table 11), however, once again mixed results were obtained. Six combinations of shoe-cleat-ankle support produced significantly fewer total injuries than expected. Four combinations produced significantly more reportable injuries than expected. By and large, however, the safest combination of equipment (with regard to total leg injuries) was seen to be conventional cleats worn with a high football shoe and either ankle wraps, tape or no ankle support. High shoes worn with disc heels and ankle wraps, high shoes worn with shortie cleats and no ankle support, and low shoes worn with disc heels and ankle wraps also proved to be safe combinations of equipment. Higher than expected rates (statistically significant) of total leg injury were sustained by players equipped with high shoes, shortie cleats and ankle tape, low shoes, conventional cleats and either ankle tape or no support, and low shoes, disc heels and ankle tape.

With regard to knee injuries (Table 13), three equipment combinations yielded lower injury rates than expected, namely, high shoes, conventional cleats and either ankle wraps or no support, and low shoes, disc heels and ankle wraps.

When data on serious (31 or more days removed from participation by a physician) knee injuries were studied (Table 15), two equipment combinations were seen to produce significantly fewer injuries than expected, namely, low shoes worn with disc heels and ankle wraps, and low shoes worn with shortie cleats and no ankle support. Low shoes worn with conventional cleats and ankle tape were seen to produce a significantly greater number of serious knee injuries than expected.

Tables 17 and 18 present analyses of serious knee injuries in terms of shoe-cleat-player position (Table 17) and in terms of cleat and player position alone (Table 18). Once again, mixed results were observed and conclusions from these analyses, which contained factors other than equipment, were passed over in favor of the outcome of a later stepwise regression analysis which included all identified factors, equipment and other.

Table 21 graphically portrays the extremely high incidence of serious knee injury sustained by players with a history of prior serious knee injuries. When the data in Table 21 were interpreted in conjunction with those in Tables 19 and 20, it became obvious that serious knee reinjury was not modified by either equipment worn or position played.

When a stepwise multiple regression analysis of 18 variables--history of previous injury, number of games played, type of cleats, type of shoes, type of ankle support, action at time of injury, position of player, conditioning, and years of experience in sports--was run for all leg injuries, as is portrayed in Table 22, only approximately 5 per cent of the variance was accounted for. However, within this spread of variables, the contributions of previous history of injury, cleat worn, and years experience in sports were found to be significant.

The computation of a stepwise regression analysis of the same variables for all knee injuries yielded somewhat similar results. The variables accounted for only 9 per cent of the variance and, within that framework, previous history of injury and years experience in sports were found to be significant.

IMPLICATIONS AND RECOMMENDATIONS

While the current endeavor was a two year study, the implications and recommendations are drawn almost exclusively from the data derived during the 1968 football season--the experimental phase of the research.

The most straightforward and clear-cut implication drawn from the data was that varsity high school football players with a history of previous serious knee injury (31 or more days removed from participation by a physician) were reinjured seriously at a rate some 15 to 17 times greater than the (initial) injury rate of players with sound knees. Therefore, it is recommended that (a) players suffering a serious knee injury be required to participate in a planned program of rehabilitation under the direction of a physician as a precondition to consideration for further varsity football competition and (b) that players with a history of previous serious knee injury be carefully and thoroughly examined by a physician at the beginning of each season in order to determine the degree of rehabilitation of the injured knee and ultimate fitness to participate. Implied here, of course, is the need for greater involvement of physicians skilled in the medical aspects of sports in the certification of youngsters for participation in football.

With regard to reducing the seriousness of injuries to the lower extremities, particularly the knee, the data indicated clearly that two equipment combinations--low shoe, disc heel, ankle wrap and low shoe, shortie cleats and no ankle support--producted a statistically significant and lower rate of injuries. Conversely, a combination of low shoe, conventional cleats and ankle tape produced a greater number of serious knee injuries than expected. It is recommended, therefore, that varsity high school football players be outfitted with low shoes and some form of disc or flat heels or short cleats. It is further

recommended that serious consideration be given to a similar modification--shortening--of the sole cleats on football shoes. The data on action at the time of injury (excluding pileups which were not included in the 1968 questionnaire) lent support to the "foot fixed to the ground" theory enunciated by Hanley and others.

It is imperative that physicians, athletic directors, coaches and other concerned with player safety in football understand clearly that the reduction of serious injuries to the lower extremities is and will continue to be an evolutionary rather than a revolutionary process. For example, if all players were immediately equipped with low shoes and drastically shortened cleats (heel and sole), the total number of serious knee injuries (328) would be reduced by only some 10-20 cases. Furthermore, if all players with a history of previous serious knee injuries were completely rehabilitated and returned to play, the total of serious knee injuries would only be reduced, statewise, by some 40-50 cases. By means of simple arithmetic it can be seen that some 257 serious knee injuries could still be expected during the course of a football season.

This is not to reduce the urgency of outfitting youngsters with the safest equipment combinations or of improving the rehabilitation and player screening processes. But it does point out that those seeking to improve the safety of the game must turn to both factors related to the condition of the organism and factors related to the nature and conduct of the sport. Further research in the area of shoe equipment may well turn out to be a somewhat unrewarding process.

With reference to the condition of the organism, more attention must be given to such areas as (1) the relative levels of physical maturity of the youngest and oldest boys eligible to compete in varsity high school football, (2) year-round programs of general physical fitness for all pupils, athletes and non-competitors, (3) year-round programs of conditioning directed to the areas of highest vulnerability of football players (the knees, for instance), and (4) extended spring or summer pre-season conditioning programs for football players. While one can be accused of overemphasizing football, the investigators believe that safety can never be overemphasized.

In the area of the rules of play governing the sport, a great deal of thought must be given to modifying or eliminating potentially dangerous situations. For example, (1) constant attention must be given to upgrading the understanding and skills of officials (who have a primary responsibility for the safety of play), (2) certain techniques such as "crack back" blocking, piling on, clipping, spearing, "blind side" blocking and the like must be discouraged by coaches and officials, (3) field zones in which clipping is legal must be restricted and (4) innovations designed to improve safety--restriction of blocking to above the waist, for example--must be tried and evaluated regardless of whether they change the "traditional" nature of the game.

SUMMARY

Through an examination of data on injuries to the lower extremities of varsity high school players (N=17,777), this study sought in 1967 to ascertain (1) whether modified cleats brought about a reduction in the number and/or severity of such injuries, and (2) whether there existed an optimum combination of equipment (shoes, cleats, ankle supports) for reduction in the number and/or severity of such injuries.

While little in the way of statistical analysis was possible, much was learned about the basic problems of data handling and interpretation. The first year's efforts also helped to identify the other variables seemingly related to injuries to the lower extremities.

In 1968, the second and final year of the study, data were gathered on the injuries to the lower extremities suffered by 17,856 varsity high school football players in New York State. By means of an arcsine transformation technique, it was determined that the lowest rate of serious knee injuries was incurred by youngsters outfitted with either low shoes, disc heels and ankle wraps or low shoes, shortie cleats and no ankle support.

Analysis of data on 204 players with a history of previous serious knee injury revealed that these players were reinjured at a rate 15 to 17 times greater than youngsters with no prior history. This experience was not modified by any one of 18 equipment combinations.

A series of stepwise multiple regression analyses indicated that 18 variables (history of previous injury, type of shoe, type of cleat, type of ankle support, experience in sports, preconditioning and the like) accounted for only between 5 and 9 per cent of the variance in seriousness of injury.

It was recommended that (1) all youngsters be outfitted with low shoes and modified heels, discs or shortened cleats, (2) consideration be given to modifying sole cleats, (3) rehabilitation and screening procedures be strengthened in order to reduce the hazards of reinjury to players with a previous history of serious injury, (4) extensive efforts be undertaken to improve the physical conditioning of all football players, and (5) that consideration be given to modifying the rules of play to increase player safety.

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